DEVICE AND METHOD FOR DETECTING CONTAMINATION IN A CONTAINER

The present invention relates to systems for selecting containers, for instance provided with labelling and/or relief patterns, for liquids such as a drink such as beer or a soft drink, for the possible

5   presence of contamination of the container.

Systems for detecting contamination present on the inside of a container are known, for instance for bottles used in a rotating system wherein these bottles are supplied to consumers a plurality of times, wherein

10 they are taken back by a supplier after a use in order to be refilled with the required product. An inspection for interior contamination can also be provided for bottles for once-only use.

Such known systems function by illuminating the

15 container from one side and then making an image recording of the illuminated bottle. Contaminants can hereby be viewed on the image recording.

However, when containers are used with a decorative exterior, for instance provided with a labelling and/or

20 relief patterns, such a system is inadequate. The decorative exterior for instance prevents viewing of the contamination and/or is itself viewed as contamination on the recording.

In order to prevent such drawbacks, the present

25 invention provides a device for detecting the possible presence of contamination of a container with a decorative exterior, for instance provided with a labelling and/or relief patterns, for liquids such as a drink such as beer or a soft drink, comprising:

30   - irradiating means for irradiating the container with at least a first wavelength,

- recording means for recording a radiation sample of radiation during interaction of the radiation with at least a part of the container,

- orientation determining means for determining the

5   orientation of the container relative to the first recording means,

- comparing means for comparing the sample to a predetermined reference matching the orientation of the container relative to the first recording means during

10 the recording.

An embodiment according to the present invention has the advantage that it can take into account the decorative exterior when determining whether contamination of the container is present. If a

15 recording is made of for instance a bottle of which the orientation is known, this can be used to determine whether there is a difference between the current bottle and this reference by means of a reference associated with this orientation, i.e. a previously recorded image

20 or a processing of previously recorded images. If this is the case, this difference indicates the presence of contamination. Such a bottle must be rejected. It is therefore possible to perform an inspection for the possible presence of contamination, even if the

25 container comprises a decorative exterior. Ornaments extending round the whole of the periphery of the container can here also be taken into account.

In a preferred embodiment the device comprises second recording means for recording radiation (1) at a

30 different moment, and/or position (2), and/or (3) with another wavelength which is generated by a second irradiating means. This radiation sample can be used to determine the orientation of the container relative to the first recording means. In a further embodiment, the

35 device comprises for this purpose means for determining

the orientation of the container relative to the first
recording means on the basis of the relative positions
of the first recording means, the second recording means
and the container at the time of the first and second
5   recording. It is not necessary here for both the
recordings to be made at the same moment or for the
container to be situated at the same position, or even
orientation, during the respective recordings. During
the inspection the container is advanced by means of a
10   conveyor and can optionally undergo an orientation
rotation that is known in advance (for instance by a
known bottle rotation in a so-called carrousel machine).
       Recording data from the second recording means are
preferably used to determine the orientation of the
15   container relative to the first recording means. These
recordings can further be used to evaluate the quality
of the decorative exterior. Use is herein made of an
assessment system as described in international patent
application WO 03/042 673 A1 of the same applicant. The
20   text of this application should be deemed as included
herein, wherein the method for generating a robust
reference image of a container and the method for
assessing a container by means of the robust reference
image are of specific importance. In preferred
25   embodiments to be described hereinbelow, the reference
for the comparing means is formed by means of a method
for producing a robust reference image of a container as
according to this earlier application. Using the images
from the second recording means it is also possible, in
30   addition to determining the orientation of the container
relative to the first recording means, to assess the
decorative exterior of the container on the basis of the
method of the above stated application.
       In a further preferred embodiment, the device
35   comprises filter means for making recordings in

optically independent manner with the recording means on
the basis of radiation of the first or of the second
wavelength. These filter means provide the advantage
that the recordings of the first recording means and
5   those of the second recording means can be made
simultaneously of a container for both the above
described objectives, i.e. detecting the possible
presence of contamination of a container and assessing
the quality of the decorative exterior of the container.
10 These filter means for instance comprise an optical
filter or an electronic filter.

An optical filter can be embodied so that it is
partly selectively permeable to radiation of a
determined wavelength range. The filter can herein be
15 placed at an angle relative to the radiation to be
transmitted or filtered. Such a filter makes it possible
to make recordings simultaneously by means of the first
and second recording means. Alternatively, it is also
possible to make the recordings one after the other.

20   The filter means can alternatively comprise an
electronic filter wherein the radiation-sensitive
elements of the recording means are for instance only
sensitive to determined wavelengths, or in which
wavelengths of different magnitudes are highlighted from
25 the data after making of the recording by the recording
means.

The first radiation sources are positioned relative
to the first recording means preferably on the rear side
of the position of the container during making of the
30 recordings, wherein the radiation irradiates the
container. It hereby becomes possible to inspect the
front and rear wall of the container simultaneously. The
device preferably comprises selecting means for
selecting a part of the recording of a part of the
35 container as assessment part, on the basis of which part

the assessment is carried out. It hereby becomes
possible to highlight the most important parts of the
container which must be selected from the whole
recording. Such a partial recording can for instance be
5   used to exclude from the inspection non-relevant
disturbances relating to the content of the container.
It may occur for instance that temporary foaming occurs
at the position of the underside of a printed label,
which could result in a container being rejected. In
10   such a case the selection can be made smaller so that
the underside of the label is not assessed. In the case
of a round container such as a bottle, the distortion
close to the sides of the recording is also relatively
great. It is therefore advantageous not to use in the
15   assessment a part of the recording having such a
distortion.

The recording means comprise at least one camera.
Such a camera may for instance be sensitive to infrared,
normal or ultraviolet light; other radiation is however
20   possible. Use can also be made of polarized light to
enable optimal detection of determined contaminants. In
the descriptions following hereinbelow, any reference to
light is also understood to include the option of using
polarized light. The use and filtering of polarized
25   light are per se known, the present invention provides
the use hereof in a detection method. The choice of such
a camera and the radiation source preferably depends on
parameters of the containers. If the container is for
instance a green bottle with a printing, a different
30   radiation source and camera combination will optionally
be chosen than when the container meets other
specifications.

In a further embodiment the device further
comprises composing means for composing, on the basis of
35   the first and/or second radiation sample and/or

predetermined parameters, a robust reference image or a
reference image with permissible deviation values, on
the basis of which image acceptable deviations in the
decorative exterior within a series of containers can be
5   taken into account during selection of containers. This
provides the advantage that statistically anticipated
deviations in containers of the same type relative to
the prescribed specification of the containers of the
same type can be taken into account.

10   The device further preferably comprises processing
means for producing, on the basis of the radiation
sample or the assessment part, a flat representation
thereof. The operation of such processing means is
likewise described in the above mentioned international
15   patent application WO 03/042 673. Such a flat
representation has the advantage that the whole
reference image is constructed in compact manner by
connecting flat part-reference images.

The first comparing means are preferably embodied
20   in order to compare the flat representation to the
robust reference image. The advantages of the above
described preferred embodiments are hereby combined.

In order to enable the comparison of the decorative
exterior by means of the second recording means, the
25   device preferably comprises second comparing means for
comparing a recording of the second recording means to a
second reference image or robust reference image for the
purpose of detecting deviations of the decorative
exterior. Using these second comparing means, a method
30   for assessing the decorative exterior can be performed
by the present invention.

The orientation determining means preferably
determine the orientation on the basis of the recording
of the second recording means. By means of recordings by
35   the first and second recording means the device can

hereby have available all information required to
determine whether possible contamination is present on
the inside as well as to determine whether the
decorative exterior meets the specifications.

5   According to a further aspect of the present
invention, there is provided a device for detecting the
possible presence of contamination of a container with a
decorative exterior, for instance provided with a
labelling and/or relief patterns, for liquids such as a

10   drink such as beer, comprising:
           - irradiating means for irradiating the container
substantially from the top or the bottom with at least a
first wavelength,
           - recording means for recording a radiation sample

15   of radiation after it has passed through at least one
wall part of the container,
           - comparing means for comparing the sample to a
predetermined reference of the container relative to the
first recording means during the recording.

20   An advantage of an embodiment according to this
aspect is that a recorded radiation sample only
comprises image information relating to the side of the
container directed toward the recording means. The
comparison can thus be made by the comparing means

25   without information relating to the orientation of the
container.
           The device according to claim 18 preferably
comprises one or more measures as specified in the
foregoing.

30   A further aspect of the present invention relates
to a method for detecting the possible presence of
contamination of a container with a decorative exterior,
for instance provided with labelling and/or relief
patterns, for liquids such as a drink such as beer,

35   comprising steps for:

- irradiating the container with radiation with at least a first wavelength by means of irradiating means,

- determining the orientation of the container relative to the first recording means,

5 - recording by means of recording means a radiation sample of the radiation after the radiation has passed through at least a part of the container,

- determining the possible presence of contamination by comparing the sample to a predetermined

10 reference matching the orientation of the container relative to the recording means,

- approving or rejecting the container.

Preferred embodiments comprise steps for determining the orientation of the container making use

15 of radiation comprising at least a second wavelength, and making recordings by means of second recording means with a sensitivity to the second wavelength.

Advantages of embodiments of this aspect of the invention are similar to those specified in the

20 foregoing.

Further advantages, features and details of the invention will be described on the basis of embodiments with reference to the accompanying figures, in which:

- fig. 1 shows a schematic representation of a

25 system according to a preferred embodiment according to the present invention;

- fig. 2 shows a schematic representation of a part of a further preferred embodiment;

- fig. 3 shows a schematic representation according

30 to a further preferred embodiment;

- fig. 4 is a schematic representation of a further preferred embodiment;

- fig. 5 shows a flow diagram of a method according to an embodiment according to the present invention;

- fig. 6 shows a schematic representation of a computer screen of an embodiment according to the present invention;

- fig. 7 is a schematic representation of a
5   computer screen according to the present invention.

Figure 1 shows a schematic top view of a first embodiment according to the present invention. One bottle B is shown, although in practice a series of bottles is transported through the detection device in
10 the direction of arrow M by means of a conveyor (not shown). At the location of the shown bottle B diverse recordings are made of the bottle in order to carry out the desired detection.

Two cameras 22, 24 are situated at an angle of for
15 instance 90°, which cameras are in this preferred embodiment sensitive to infrared radiation or light in the infrared range. Depending on the type of bottle or other container, and the decorative exterior thereof, other recording means or cameras with a sensitivity to
20 other wavelengths can be applied.

Opposite each camera 22, 24 are situated infrared light emitters 2, 4 which can emit infrared radiation R in the direction of the cameras. The infrared light radiated through bottle B is then picked up by means of
25 cameras 22, 24.

The system further comprises processing means 36, comprising for instance a computer for processing the recording data from cameras 22, 24. Processing means 36 can also comprise two computers, one for each camera.
30   In the detection of contamination in accordance with the setup described up to this point, processing means 36 receive, per image recording, images which comprise the possible contamination as well as data relating to the decorative exterior, such as labelling
35 that is present and/or relief patterns in the glass of

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the bottle. If every presence of radiation-blocking
elements in the wall of the bottle were to result in
rejection of a bottle, information relating to the
labelling and/or the relief patterns would be assessed
5   as contamination and therefore result in rejection of
the bottle. This is undesirable. Information relating to
the relief patterns and the labelling is therefore
stored in the memory means of computer 36. Using this
stored information, account can be taken of this
10   information by means of a suitable processing, so that
the labelling and/or the relief patterns will not result
in rejection.

This information is present in the form of
reference images. In order to take into account
15   acceptable, for instance slight deviations in the
decoration, the acceptable deviations within a type of
bottle are included in a so-called robust reference
image by means of statistical processes in a manner
known from WO 03/042673. These robust reference images
20   are stored per type of bottle, whereby a plurality of
types of bottle can be processed with the same method
using one device. For the sake of completeness, this
processing is further explained hereinbelow.

A further improvement in the efficiency with which
25   one or more processing unit(s) 36 performs the
inspection is by storing a plurality of robust reference
images. 120, 360 or 720 robust reference images of a
bottle are for instance stored here, with a relative
rotation of respectively 3, 1 or half a degree. By means
30   of a suitable processing the computer can hereby use the
most closely matching reference image for the present
recording of bottle B.

In order to efficiently select the correct robust
reference image with the correct orientation during the
35   recording, the orientation of the bottle relative to

camera 22, 24 is preferably known. Camera 32 is situated
for this purpose in the device. Camera 32 serves to make
an elevation recording of the exterior of the bottle, on
the basis of which recording processing unit 34, which

5   either comprises a program which functions on the same
computer as processing unit 36 or can be provided in a
separate computer, serves during the recording to
determine the orientation of the bottle on the basis of
this recording. Using the orientation of bottle B

10   determined by means of the recording of camera 32,
processing unit 36 can determine the robust reference
image with the correct orientation. For an optimal
result of the recording of camera 32, an illumination of
bottle B is further provided from the front side

15   relative to camera 32. Arranged for this purpose
adjacently of the conveyor of the bottles is a bracket
11 in which are situated the ends 12 of light-conducting
fibres such as glass fibres 10. By means of these glass
fibres 10 light from a light source 8, which is

20   centralized by means of a reflector 6 and which is
filtered by means of a filter 14, is supplied to the
bracket.

      The wavelength of lamp 8 is preferably different
from that of radiation sources 2 and 4. Cameras 22 and

25   24 on the one hand and camera 32 on the other hereby
function without influencing each other.

      Filters 14, 26 and 28 are provided in order to
further reduce this mutual influencing. When the
wavelength as specified in the foregoing is used in this

30   embodiment, filter 14 serves to filter out infrared
light generated as side-effect by source 8. Filters 26,
28 further serve to filter out the for instance visible
light of light source 8. An alternative method of
filtering is by means of a semi-specular filter 26,

35   disposed at 45˙, which reflects the visible light

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sideways and is permeable to the infrared light. In this
version the filter placed at 45° to the infrared beam
can reflect the visible light in the direction of a
camera 32 which is directed at the obliquely placed

5   filter. This version is not shown.

    Figures 2, 3 and 4 show schematically alternative
embodiments of the camera layout. Fig. 2 herein shows a
doubling of the camera arrangement of fig. 1. Cameras 42
and 44 correspond here to the cameras of the first type

10   22 and 24 of fig. 1, and camera 46 corresponds to the
camera of the second type 32 of fig. 1. Since this
camera layout inspects a part of the bottle, in this
embodiment a second camera layout is arranged on the
other side of the conveyor. Cameras 48 and 49 of the

15   first type are herein used for the same function as
cameras 42 and 44, and camera 47 of the second type is
used for the same function as camera 46. Illuminating
means as according to the embodiment of fig. 1 are
likewise present in this embodiment in a manner which is

20   not shown.

    Fig. 3 shows a conveyor 50 with a series of bottles
B thereon. Module 51 serves to rotate the bottle through
a predetermined number of degrees between measurements
by the first camera group, comprising cameras 52 and 54,

25   and the second camera group, comprising cameras 56 and
68. This angle is for instance 90°. Cameras 52 and
optionally 56 are of the first type for making a
recording of the decorative exterior of the bottle, and
cameras 54 and 58, and optionally 56, are of the second

30   type for making the recording (with for instance
infrared light, as specified in the foregoing) for the
contamination inspection on the interior. The recordings
of camera 52 and optionally 56 serve to determine the
position of the bottle relative to the camera of the

35   first type.

A further embodiment (fig. 4) shows a measuring arrangement in a carrousel. The carrousel herein rotates in the direction of the arrow R. Two cameras 64, 66 of the first type make recordings, and a camera 62 of the

5 second type for determining the orientation of the bottle also makes recordings. The illuminating means are not shown in this schematic representation. A rotation unit 61 can optionally be incorporated in the carrousel for the purpose of rotating the bottle to a second

10 orientation in order to obtain more measurement data of a bottle.

Other embodiments are also possible, wherein at least one camera of type one and at least one camera of type two are used, and the bottle rotates a known number

15 of degrees between the two camera recordings. The use of a plurality of cameras per type will increase the detection reliability. The detection reliability will also be increased by focussing the camera on the front side of the bottle and applying an extra camera for the

20 rear of the bottle.

In the above described embodiments the position of the lighting and the camera relative to the bottle can be varied by means of placing mirrors between the lighting, the bottle and the camera in appropriate

25 manner. It hereby becomes possible for instance to place all cameras parallel to the conveyor, whereby the device can be given a relatively compact form.

The operation of processing units 34 and 36 is now set forth with reference to fig. 5. The steps 101, 104-

30 109 are performed by processing unit 34 of the embodiment of fig. 1. Steps 110-116 are performed by processing unit 36 of the computer of fig. 1. The recorded image 110 is fed to the processing unit. Step 111 makes use of information originating from step 104,

35 the recorded image from a camera of the first type 110

and a reference image 117 stored in a memory of the computer.

A number of reference images is stored per type of bottle. These are for instance 360 images, or one image per degree of rotation, or 720 images, or two images per degree of rotation. Using such a quantity of images a suitable reference image can be chosen at each orientation of the bottle relative to the camera of the first type. In step 111 the correct reference image is selected on the basis of the orientation data obtained from step 104, which reference image is then used as compensation for recorded image 110, the orientation of which is obtained from step 104.

From this step 111 there results a differential image 112. This differential image 112 undergoes a further processing in step 113. In order to prevent unnecessary rejection of bottles on the basis of production variations during arranging of the labels or the relief patterns, a robust reference image in which acceptable differences are processed in statistical manner is taken into account in this step. The acceptable differences which can be detected in differential image 112 as a result of product variations are eliminated by means of step 113 by compensating the so-called robust differential image with (for instance by subtracting it from) differential image 112. The result of this processing is filtered differential image 114. 360 or 720 variants of the robust differential image 118 are for instance also stored. This is advantageous for both images 117, 118, since using these stored images relatively little computing power is required to select the correctly oriented image for performing this method. An alternative herefor is that a suitable reference image is first selected on the basis of an overall recording of the bottle, by means of

processes requiring a relatively large amount of
computing power.

        The filtered differential image of 114 is then
analysed in step 115. This filtered differential image
5   is shown in fig. 7 by means of reference numeral 86. It
can be seen clearly here that a dark dot is present,
which will have to result in rejection. The result of
this analysis is an indicator 116 which can either have
the value of approved or rejected.

10   Figure 7 shows an example of a graphic
representation of a software program suitable for
performing the method for detecting the possible
presence of contamination of the bottle with the
decorative exterior. Operation takes place here on the
15   basis of a translucent image wherein the light radiates
through the bottle for a recording. Several software
control buttons of the software are shown at the top. On
the left is shown the recording 83 of the bottle which
corresponds with received image 110, having therein in a
20   rectangle the area for assessing, comprising for
instance 60 degrees of the periphery of the bottle. In
this representation a solid with a square around it is
shown at the bottom of the label. This solid represents
a contamination of the bottle behind the label.

25   Adjacently above this latter the reference image
which is a recording of an irradiated standard bottle of
this type is indicated by numeral 82. This corresponds
to reference image 117 from the method description.
Below this the received translucent image 84 (in the
30   same way as image 110) is shown once again reduced in
size. The contamination can also be viewed hereon at the
same position as in representation 83. Adjacently
thereof the differential image 85 corresponding to
differential image 112 is shown. This differential image

is the difference between the representation of 84 and
that of 82. The contamination is also visible hereon.

In the representation of differential image 85 the
broken lines show that an individual bottle is subject
5   to production deviations in respect of the decorative
exterior. The alignment of a label can vary somewhat, as
well as the positioning thereof. In order not to allow
an imperfectly positioned or dimensioned label to result
in rejection as if it were contamination, this
10 differential image 85 is compensated with the robust
differential image or mean differential image 118. The
result of this process is representation 86, in which
all residues of the decorative exterior, being the
labels and relief patterns, are eliminated. The
15 contamination remains visible after these treatments. A
bottle is rejected on the basis of the detected
contamination.

Set forth in the foregoing is the method for
inspecting a bottle with a label and relief patterns
20 arranged thereon. In a preferred embodiment use is
herein made of the orientation of the bottle relative to
the camera of the first type during the recording. This
recording for determining the orientation is preferably
combined with a recording for inspecting the quality of
25 the decorative exterior, or the label and the relief
patterns.

For this purpose a recorded image 101 is made by
means of camera 32. In step 104 a part of this recorded
image which is important is processed into a flat
30 representation of the exterior of the bottle. This
representation corresponds to an exterior of the bottle
placed in a flat plane. On the basis of label reference
image 102 it is then determined which part of this
reference image corresponds with recorded image 101. The
35 orientation of the bottle relative to the camera is then

calculated on the basis of this operation. Data relating
to this orientation from step 104 are fed to step 111.
In step 104 the label reference image 102 is then
processed with the recorded image 101. This results in
5   the label differential image 105.

In order to be able to take into account natural or
acceptable differences between manufactured bottles in
respect of the printing on the exterior, the mean label
differential image 103 is composed. This mean or robust
10   label differential image 103 comprises known or measured
data relating to acceptable deviations relative to the
specifications of the bottle. In step 106 the label
differential image 105 is compared to the mean label
differential image 103 by means of a calculating
15   operation. This results in the filtered differential
image 107. In step 108 an assessment is made as to what
extent the resulting filtered differential image 107
comprises information relating to unacceptable
differences. On the basis of this analysis the bottle is
20   approved or rejected in step 109.

The mean label differential image 103 and the mean
differential image 118 for the side wall inspection are
produced during a learning procedure with a series of
"good" bottles. A sufficiently large series of "good"
25   bottles contains a number of bottles which fall just
within the tolerance in respect of the quality of the
label and/or the relief patterns. The quality margin of
the mean differential images is determined on the basis
hereof. For every 1 degree of rotation for instance a
30   mean differential image 118 is produced on the basis of
translucent radiation. During recording of images for
producing the mean differential image 118 it is
important that the orientation is known in order to
determine each of the for instance 360 mean differential
35   images 118. It is however recommended that the

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orientation of the bottle is known during normal
operation. It is however also possible to perform the
method 110-118 without the orientation being known. In
step 111 a greater amount of computing power is here
5 required to determine the orientation in order to enable
comparison of the received image 110 with the reference
image in the correct orientation.

Figure 6 relates to a screen representation of a
software program used to determine the orientation of
10 the bottle relative to the camera, and optionally to
determine the quality of the decorative exteriors. Here
73 relates to a representation of an elevation recording
of the bottle having therein a rectangle which relates
to the part of the bottle to be assessed. The deviation
15 herein also becomes relatively great close to the edges
of the recording. Representation 72 relates to an
exterior of the bottle which has as it were been laid in
a flat plane. Representation 73 relates to the recording
102. Representation 74 relates to the "unrolled" image
20 which is made in step 104 of the received image 101 for
comparison to the label reference image 102. The
orientation of the bottle can be determined on the basis
of this comparison.

In order to determine the quality of the label on
25 the exterior, the label differential image 105 is
produced, this being shown in representation 75. All
possible colour of the label is hereby also used and
processed in order to arrive at a representation in grey
tones representative of deviations. Finally, the
30 filtered differential image 107 is shown by means of 76.
In this case it is a label without deviations. In the
case of deviations, spots of a determined pixel size are
shown in representation 76. If the spots include a
sufficient number of pixels, a decision is made to
35 reject the label. (A combination of) other criteria,

such as shape or location of the deviation, can also result in rejection.

Different aspects of the above described embodiments can be mutually varied in order to arrive at
5   non-described specific embodiments. The rights sought are defined by the appended claims.